

CHAPTER I

INTRODUCTION

Concerns related to the depletion of fossil fuel reserves, as well as environmental and public health problems caused by automotive and power regeneration sources make hydrogen, in combination with fuel cells, an attractive alternative energy source. Hydrogen has great potential as an environmentally clean energy carrier. Hydrogen, in combination with fuel cells, is being considered as an environmental friendly source of energy for automotive as well as stationary applications. Hydrogen has the significant advantage of producing no air or other pollutants in its transformation to energy, while fuel cells, which operate primarily on hydrogen, offer enhanced efficiency in power generation (Basagiannis *et al.*, 2006).

Since hydrogen does not exist on earth as a gas, it must be obtained from other compounds such as water, biomass, and natural gas (Ekaterini *et al.*, 2009). There are many processes to produce hydrogen. The major process is a refining process from fossil fuels such as natural gas, naphtha and heavy oil that occur some environmental and public health concerns. To avoid these concerns, there have been some developments of alternative source for hydrogen production from renewable energy feedstock such as biomass, i.e., anaerobic digestion, fermentation, gasification and pyrolysis. This process can reduce substantially the amount of carbon dioxide released and consider as environmental friendly.

The recent attractive process to produce hydrogen from renewable energy source is the steam reforming of the bio-oil produced from fast pyrolysis of biomass. Bio-oil consists of 20% organics, e.g. acetic acid, ethylene glycol, acetone, ethylene acetate, xylenes and glucose and 80% water. Acetic acid is one of the major components in bio-oil (up to 12%). Acetic acid is noninflammable so it is a safe hydrogen carrier and chosen as a model compound. Several experiments and theoretical studies have been carried out on steam reforming of acetic acid (Evans *et al.*, 1987).

Catalytic activity for steam reforming of acetic acid depends appreciably on the nature of the dispersed metallic phase. Ni-, Rh- and Ru-containing catalysts, were found to be the most active ones, while Pt and Pd catalysts exhibited much lower activity. The nature of the support also plays a significant role in the reaction of steam

reforming. Addition of basic oxides such as La_2O_3 , CeO_2 and MgO , to Ni and Ru catalysts supported on Al_2O_3 resulted in significant improvements of their catalytic activity. Carbon deposition is favored over alumina carrier (Basagiannis *et al.*, 2007).

The Ni metallic phase supported on metal oxides such as Al_2O_3 , $\text{Ce}_{0.75}\text{Zr}_{0.25}\text{O}_2$, and MgO were investigated for the steam reforming of acetic acid. The catalytic activity and carbon formation for the catalysts studied were significantly dependent on the Ni content and the nature of support. The 15% Ni/ $\text{Ce}_{0.75}\text{Zr}_{0.25}\text{O}_2$ catalyst exhibited the highest catalytic performance in terms of C–C breakage conversion and hydrogen yield. In addition, the redox properties of $\text{Ce}_{0.75}\text{Zr}_{0.25}\text{O}_2$ provided higher stability than the MgO and Al_2O_3 due to its less carbon deposition even at low steam-to-carbon ratios (Thaicharoensutcharittham *et al.*, 2011).

Since the steam reforming process is a highly endothermic process demanding an efficient heat supply to the system and operates at high temperature with Ni-based catalysts, it seems to be not economical and has some major problems in coke formation (Trane *et al.*, 2012).

The purpose of this work is to alleviate such problems using autothermal steam reforming by applying both steam and oxygen together as oxidants to reform the hydrocarbon feed into hydrogen rich stream. This research will investigate on the optimum condition for the autothermal steam reforming of acetic acid over 15%Ni/ $\text{Ce}_{0.75}\text{Zr}_{0.25}\text{O}_2$ catalyst in terms of catalytic activity and stability.